Stimulating Investment and the Telecommunications Act of 1996

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Abstract

The Telecommunications Act of 1996 required incumbent local exchange carriers (ILECs) to unbundle their networks in order to provide non-discriminatory and cost-based access to the elements that comprise the ILECs' local networks. This legislation was intended to facilitate the emergence of local competition by reducing barriers to entry faced by competitive local exchange carriers (CLECs). Since its passage, the ILECs have resisted complying with these rules. The ILECs now claim that their resistance is grounded in good public policy because, they allege, current unbundling rules reduce ILEC and CLEC incentives to invest in infrastructure. A contrary view is that the rules – if properly implemented and enforced – promote competition that encourages investment by ILECs and CLECs alike. This paper reviews the theoretical arguments on both sides and then subjects these two theories to an empirical test, using data on ILEC investment and CLEC competitive behavior since the passage of the Act. As we explain further below, both the theoretical, and especially the empirical analysis provide a strong refutation of the ILEC argument that mandatory unbundling provisions deter ILEC and CLEC investment. Specifically, we estimate that a 1% *reduction* in UNE rates corresponds with approximately a 2.1% to 2.9% *increase* in ILEC investment. Thus, we conclude that unbundling of ILEC networks promotes competition, and thereby stimulates investment in telecommunications infrastructure by incumbents and entrants alike.

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Executive Summary

I. INTRODUCTION AND SUMMARY

In the debate over the implementation of the Telecommunications Act of 1996 incumbent local exchange carriers (ILECs) have argued that mandatory unbundling denies them a fair return on their investments and thereby diminishes their incentives to make investments in network infrastructure and encourages "free riding" on the part of competitive local exchange carriers (CLECs). Based on this view, the ILECs argue that they should not be required to provide CLECs broad access to unbundled network elements (UNEs). In contrast, CLECs have argued that the competition created by the availability of UNEs, which brings about lower prices and better quality, induces the ILECs to increase investment in their network facilities. We refer to these two competing views as the *Investment Deterrence* and *Competitive Stimulus* hypotheses, respectively.

There are strong theoretical reasons for preferring the *Competitive Stimulus Hypothesis* over the *Investment Deterrence Hypothesis*. The availability of UNEs quite plainly facilitates local telephone competition and total industry investment expands as competition results in lower prices, increased demand, and improved customer choice and service quality. More specifically, ILECs enjoy enormous advantages over new entrants as a result of their legacy as protected franchise monopolists that currently serve over 90% of existing demand. ILECs benefit from large economies of scale and scope and enjoy important first mover advantages relative to CLECs with respect to rights of way and placement of outside plant and structure. The ILECs are also protected by sunk cost entry barriers – *i.e.*, entry by CLECs is very risky because many of the costs of local networks are sunk, and therefore cannot be recovered if the CLEC ultimately is unable to remain viable in its competition with the incumbents.

Clearly, when it is economically viable to do so, a CLEC would prefer to own its facilities so as to avoid having to be dependent on its largest competitor for essential inputs. But because of economies of scale, it is not economically practical for CLECs to replicate the ILEC network or, in many instances, even particular piece-parts of that network. UNEs, however, permit CLECs to share incumbent scale economies and provide competition using shared facilities in those many instances where deploying alternative facilities is not feasible.

Further, UNEs can facilitate deployment of alternative facilities by CLECs in those limited instances where it is potentially economic to do so. For example, UNEs allow CLECs to grow sufficient scale in order to justify economic investment in their own facilities. Likewise, UNEs can serve as a "bridge" that allows a CLEC to overcome sunk cost entry barriers. UNEs permit a CLEC to gain a customer base first and then build facilities once it is clear that the CLEC has sufficient demand profitably to deploy those facilities.

When priced using the Commission's TELRIC standard, UNE rates fully compensate ILECs for the economic costs of providing UNEs, including a risk-adjusted

return on the ILECs invested capital. TELRIC-based UNE rates, therefore, approximate the prices that would prevail for UNEs if there were a competitive wholesale market. So long as CLECs are paying rates that are at or above TELRIC, "free-riding" cannot occur.[1]

In contrast, the *Competitive Stimulus Hypothesis* follows naturally from our expectation and understanding of competitive markets. The increased competition enabled by UNEs can be expected to result in lower retail prices both because of the efficiency improvements induced by competition and because of the pressure competition places on above-cost pricing. Lower prices will result in increased demand. The growing demand will induce additional facilities investment by ILECs and CLECs. Additionally, in a competitive environment, both the incumbent and the entrant will face enhanced incentives to improve quality and innovate with respect to services, leading to further investment.

The conclusion that emerges from basic economic theory is further supported by an empirical analysis of CLEC and ILEC investment behavior since the passage of the Telecommunications Act of 1996. The cross-sectional variation in the terms and conditions upon which UNEs are available in the states allows us to test the linkage between the availability of UNEs, CLEC competitive activity, and ILEC investment in network infrastructure.

To accomplish this analysis, we use standard econometric tools that are widely accepted in the field. We use a variety of techniques to measure directly how ILEC network investment is impacted by competition from CLECs. We also measure how CLEC entry is impacted by the availability of UNEs. In doing so, we rely principally on accepted and publicly available data.

As we explain in greater detail below, our results unambiguously refute the *Investment Deterrence Hypothesis*, and provide strong support for the *Competitive Stimulus Hypothesis*. Overall, we estimate that a 1% *reduction* in UNE rates corresponds with approximately 2.1% to 2.9% *increase* in ILEC investment. Thus, restricting access to UNEs, as the ILECs advocate, would *both* reduce the competitive alternatives available to consumers *and* reduce the ILECs' capital spending in their networks.

II. EMPIRICAL TEST AND RESULTS

As discussed above, the *Investment Deterrence* and *Competitive Stimulus* hypotheses make different predictions regarding the effect of UNE prices on ILEC investment. We employ a state-by-state cross section of data to carry out regression analyses to test which of these two hypotheses has greater empirical support.

[1] Indeed, some might argue that prices below TELRIC might be justified because (1) accelerating the realization of effective competition would enhance total welfare; and (2) much of the ILECs' sunk investment has already been recovered, and hence, per unit TELRIC significantly overstates the long-run incremental cost for capacity faced by the incumbent, even if it does accurately reflect the long-run incremental cost faced by a new entrant.

Our empirical analysis proceeds in two stages. First, to distinguish between the competing predictions made by the two hypotheses, we conduct an analysis that investigates the relationship between ILEC investment and UNE prices. To the extent that this "reduced-form" relationship is positive, *i.e.* if higher UNE prices are associated with greater ILEC investment, the *Investment Deterrence Hypothesis* is supported. To the extent that this relationship is negative, *i.e.*, if lower UNE prices are associated with greater ILEC investment, the *Competitive Stimulus Hypothesis* is supported.

We find statistical evidence that this relationship is *negative* and, therefore, that the empirical evidence refutes the *Investment Deterrence Hypothesis* and is consistent with the *Competitive Stimulus Hypothesis*. Our reduced-form regressions are statistically significant and explain a large share of the variation in the dependent variable, ILEC investment. Moreover, the estimated effects of various other independent control variables include statistically significant estimates that are consistent with the underlying economic theory.

Having found confirmation of the *Competitive Stimulus Hypothesis*' prediction in the first stage, we turn in the second stage of our analysis to test directly the mechanism of the *Competitive Stimulus Hypothesis* using "structural-form" relationships. According to the *Competitive Stimulus Hypothesis*, lower UNE prices lead to greater CLEC activity, and greater CLEC activity leads to greater ILEC investment. We therefore estimate the effect of UNE prices on CLEC activity and the effect of CLEC activity on ILEC investment. Again, we find a negative relationship between UNE prices and CLEC activity, *i.e.*, that higher UNE prices lead to less CLEC activity, and a positive relationship between CLEC activity and ILEC investment, *i.e.*, that greater CLEC activity leads to greater ILEC investment. Notably, these results are obtained in the context of regressions that are themselves statistically significant, explain a high share of the variation in the dependent variable and produce estimates consistent with economic theory.

III. RESPONSE TO CRITIQUES

An earlier version of this analysis based on a less complete data set was included in a filing to the Federal Communications Commission (FCC) by Professor Willig. The principal challenge to that paper was that he had relied on UNE-P rates from June 2002 to explain CLEC activity and ILEC investment from earlier periods.

The results we report in this paper are obtained using UNE price data from a variety of sources compiled at various times between 1996 and 2002. Our data include UNE-P rates compiled by AT&T in 2002 as well as Regulatory Research Associates TeleFOCUS estimates from August 2000; the National Regulatory Research Institute's estimates from Spring 2001 and July 2002; and the loop proxy rates established by the FCC in its August 1996 First Report and Order. We continue to find empirical support for the *Competitive Stimulus Hypothesis* and reject the *Investment Deterrence Hypothesis* using UNE price data from as early as 1996 as well as with data from 2002. Our conclusions are not dependent on the time at which the UNE-P rates were compiled.

IV. ALTERNATIVE ANALYSES

Finally, we have reviewed alternative treatments of the relationship between UNE prices or the level of CLEC activity and ILEC investment that have been proffered by our critics. As we explain below, both analyses are severely flawed, and hence, provide no useful insight into the merits of the FCC's unbundling policies.

John Haring *et al.*[2] purport to explain the relationship between ILEC investment and UNE pricing by running a regression in which regional Bell operating company (RBOC) net plant in a state is a function of the number of RBOC loops, the number of unemployed persons in the state, real gross state product, and the product of the number of RBOC loops and the UNE loop price for zone 1. This relationship has neither any basis nor any meaningful interpretation in economic theory. In fact, Haring, *et al*. have effectively performed the equivalent of a regression tautology. Haring, *et al*. use RBOC net plant as the dependent variable, but then employ an equation where that dependent variable is a function of loops. They then examine whether total net plant is larger when the aggregate value of loops is larger (where loops are valued at the zone 1 UNE loop price). Not surprisingly, they find that this is the case. This is flawed because loops constitute a significant portion of net plant, so the result will likely be a positive relationship as a matter of arithmetic rather than as a policy-relevant causal relationship. Further, use of net plant as the dependent variable is flawed because the relevant issue is how the availability of UNEs effects *investment*. Investment is effectively indicated by *changes* in net plant rather than the level of net plant.

A second study prepared by a group of RBOCs examines the relationship between total ILEC investment per line and CLEC UNE-P lines per 1000 RBOC access lines.[3] The authors chief result is their finding that ILEC investment per line does not increase when the number of CLEC UNE-P lines increases. They conclude from this that there is no relationship between UNE unbundling and ILEC investment. This conclusion, however, is not supported by the regressions estimated in the report. First, it appears that the authors make the same mistake as Haring *et al.*, they confuse the stock of capital per line with investment which might be measured by the *change* in the level of capital per line. Second, the authors fail to include controls for other significant factors that could be reasonably expected to affect the relationship between ILEC capital per line and the proportion of lines served by CLECs using UNE-P. There are no controls for demand factors, the cost of telecommunications infrastructure, or the effects of regulation. As a matter of basic econometrics, the omission of such highly relevant variables means that

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[2] *UNE Prices and Telecommunications Investment by John Haring, Margaret L. Rettle, Jeffrey H. Rohlfs, and Harry M. Shooshan III, Strategic Policy Research, Submitted on behalf of Qwest*, in its reply comments in the Matter of Review of the Section 251 Unbundling Obligations of Incumbent Local Exchange Carriers, CC Docket No. 01-338 (July 2002).

[3] *UNE-P and Investment, Prepared for and Submitted by BellSouth, SBC, and Verizon*, In the Matter of Review of the Section 251 Unbundling Obligations of Incumbent Local Exchange Carriers, CC Docket No. 01-338 (July 2002).

the estimates obtained are biased and unreliable. Third, the data relied upon for this analysis are incomplete and severely flawed.

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I. INTRODUCTION

Prior to 1996, local telecommunication markets were served by monopolies protected by regulation. The Telecommunications Act of 1996 put in place a new regulatory framework to be implemented by the Federal Communications Commission (FCC) that was intended to facilitate the transition to competition. The pro-competitive unbundling provisions adopted in Sections 251 and 252 of the 1996 Act were key components of this framework. Absent unbundling, competitive entry into local services was not economically feasible. The economic barriers to entry in the face of an entrenched incumbent that owned the only ubiquitous network infrastructure in its serving area and provided retail services to over 90% of the customer lines were simply too daunting.

Although the economic case for mandatory unbundling was clear, it was recognized that the Incumbent Local Exchange Carriers (ILECs) would not be motivated to comply willingly with the pro-competitive provisions.[5] After all, realizing the Act's goal of promoting sustainable local competition would result in a reduction in the market

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[5] See, for example, William J. Baumol and J. Gregory Sidak, *Towards Competition in Local Telephony*, (The MIT Press, 1994), pp. 121–24; and First Report and Order, In the Matter of Implementation of the Local Competition Provisions of the Telecommunications Act of 1996, 11 FCC Rcd. 15499, ¶¶ 9, 14 (1996) (hereafter "FCC First Report and Order.")

power of the ILECs. Increased competition would force the ILECs to cede market share to Competitive Local Exchange Carriers (CLECs) and would result in lower prices and a greater share of total surplus being captured by consumers instead of telecommunication service providers. The ILECs have recurrently resisted implementation of the Act on many fronts.[6]

The ILECs latest effort is to claim that mandatory unbundling reduces their incentives to invest in infrastructure. They argue that mandatory unbundling denies ILECs a fair return on their investments and encourages "free-riding" by the CLECs on ILEC facilities.[7] We refer to this argument as the *Investment Deterrence Hypothesis*.

A contrary view – and one that is more consistent with the intent of the Act – is that unbundling is necessary for and helps promote efficient competition. Competition brings lower prices, improved service quality, and expanded consumer choice. ILECs and CLECs are both induced by competition to increase investment in order to serve the enlarged market and to better serve consumers who are more demanding and empowered when given real choices as to where to purchase their telecommunication services. According to this alternative view, which we call the *Competitive Stimulus Hypothesis*, unbundling promotes competition which in turn encourages investment.

In Section II, we review the theoretical support for these two perspectives. This analysis demonstrates that the *Competitive Stimulus Hypothesis* is consistent with economic theory, while the *Investment Deterrence Hypothesis* may be valid only if the use of unbundled network elements (UNEs) by CLECs imposes an uncompensated negative externality on ILEC productivity, a not impossible, but unlikely proposition.

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[6] The core market opening provisions of the Telecommunications Act have been repeatedly challenged in court by the ILECs, see *Iowa Utils. Bd.* v. *FCC*, 120 F.3d 753 (1997); *BellSouth Corp. v. FCC*, 162 F.3d 678 (D.C. Cir. 1998); and *Verizon Communications Inc. v. FCC*, 122 S. Ct. 1646, 1672 (2002). SBC's resistance to the Act has been so strong that it has incurred tens of million of dollars for failure to provide adequate wholesale access to competitors. *Communications Daily*, Vol. 22, Issue 185 (Sept. 24, 2002).

[7] Alfred E. Kahn, "Whom the Gods Would Destroy, or How Not to Deregulate," AEI-Brookings Joint Center for Regulatory Studies (2001).

Although this theoretical analysis is compelling by itself, there is also a substantial set of market data that can be used to test whether these hypotheses have empirical support or whether they are inconsistent with the data. In Section III, we use the cross-sectional variation across the states in rates for UNEs, in ILEC investment behavior, and in CLEC competitive activity to perform econometric tests of the two hypotheses. Our results strongly reject the *Investment Deterrence Hypothesis*, and provide support for the *Competitive Stimulus Hypothesis*. Based on our analysis, we calculate the elasticity of ILEC investment with respect to UNE prices is between -2.1 and nearly -2.9. Thus, for every 1% increase in the UNE price, ILEC investment declines by approximately 2.1% to 2.9%. In Section IV, we respond to several critiques of our analysis that have been advanced since our initial results were first publicized. Finally, Section V summarizes our conclusions and policy recommendations.[8]

II. COMPETITION, INVESTMENT, AND UNBUNDLED NETWORK ELEMENTS

In this section, we examine the economics of telecommunications investment, access to unbundled network elements, and the theoretical foundations of the two competing hypotheses we study.

A. Investment And Competition

Understanding the effect of unbundling rules on investment incentives is part of the context within which telecommunications regulators must make decisions about the pace at which competition is introduced into telecommunications markets and the extent of the competition that should be encouraged. If, on the one hand, a pro-competitive environment is inimical to investment in telecommunications infrastructure, then policy makers will constantly face the need to weigh the trade-off between current economic

[8] Earlier versions of the analysis presented here were included in *Reply Declaration of Robert D. Willig on Behalf of AT&T*, In the Matter of Review of the Section 251 Unbundling Obligations of Incumbent Local Exchange Carriers, CC Docket No. 01-338 (July 2002); and in *Declaration of Robert D. Willig on Behalf of AT&T*, In the Matter of Review of the Section 251 Unbundling Obligations of Incumbent Local Exchange Carriers, CC Docket No. 01-338 (April 2002).

efficiency, which is enhanced by a competitive environment, and long-term economic growth, which is enhanced by an environment that encourages investment.

On the other hand, to the extent that pro-competitive policies also *encourage* investment, there is no trade-off to be made by regulators. The same policies may be used in support of both objectives, freeing policy makers of the need to decide, in effect, how much monopoly power to tolerate in exchange for what amount of growth.[9]

B. UNEs And Competition

The ILECs' statutory obligation to provide non-discriminatory access to UNEs, in effect, recognizes the special role such access plays in promoting competition in the provision of local and other telecommunications services. The ILECs' provision of such local services is characterized by substantial economies of scale and scope.[10] In addition, ILECs enjoy important first mover advantages relative to CLECs with respect to rights of way needed to provide transport and loops as well as access to customer buildings to provide loops. For CLECs to compete via their own facilities, they must sink the cost of investment that is sufficiently substantial to enjoy economies of scale and scope comparable to those enjoyed by the ILECs. Consequently, absent CLEC access to UNEs on non-discriminatory terms, ILECs enjoy the strategic advantage of a cost structure with significant natural monopoly characteristics in a non-contestable market. In this setting, absent regulation, ILECs would be able to sustain supra-competitive prices without fear of being undercut by competition from new entrants.

For effective competition to succeed, therefore, CLECs must have access to UNEs on non-discriminatory terms, along with the rights to employ the UNEs as inputs

[9] Moreover, if local competition is *not* successful and the market remains monopolized, then policy-makers will continue to be required to provide monopoly regulation for the foreseeable future.

[10] See, for example Alfred E. Kahn, *The Economics of Regulation: Principles and Institutions*, Vol I. (John Wiley and Sons, 1970), pp. 124–30, or the FCC's own explanation of the benefits of unbundling, "Congress recognized in the 1996 Act that access to the incumbent LECs' bottleneck facilities is critical to making meaningful competition possible. As a result of the availability to competitors of the incumbent LEC's unbundled elements at their economic cost, consumers will be able to reap the benefits of the incumbent LECs' *economies of scale and scope*, as well as the benefits of competition." FCC First Report and Order ¶ 679 (emphasis added).

and as a platform for rivalrous entry into other related services. It is predictable in this setting that the ILECs will not be motivated to make such access available unless compelled to do so. Even in areas where CLEC facilities-investment could potentially prove viable, UNEs can play an important role in helping CLECs grow sufficient scale in order to justify investment in their own facilities. Also, UNEs can serve as a "bridge" to facilities deployment by CLECs thereby diminishing sunk cost entry barriers. UNEs permit a CLEC to acquire a customer base and then deploy facilities to serve those customers once it is clear that there is sufficient demand to support them.

C. The Investment Deterrence Hypothesis

According to the *Investment Deterrence Hypothesis*, mandatory unbundling discourages ILEC investment by rendering it less profitable than it would be in the absence of unbundling. According to this view, unbundling rules compel the ILEC to lease portions of its local exchange network to CLECs at returns that are lower than it can earn when it uses this network to provide retail services to customers. The combined return accruing to the ILEC from its local network investment is, therefore, diminished and with it the ILEC's incentive to invest.

Although superficially appealing, this argument is inconsistent with the basic economics of competition and monopoly. Consider an ILEC that does not face mandatory unbundling. Like any rational firm, the firm's investment will be governed by the rule that the firm will install any unit of capital contributing to network infrastructure as long as the marginal revenue product of that unit of capital (*i.e.,* the incremental revenue that may be earned from installing the incremental unit of capital to the network and selling the incremental services produced thereby) exceeds the marginal cost of acquiring that unit of capital. Absent competition, the ILEC's marginal revenue product of capital is determined by the level and sensitivity of customers' willingness to pay a monopoly provider and any regulation to which the firm is subject.

The existence of effective competition changes the ILEC's marginal revenue product. Although total net revenue may be smaller than it was under monopoly, the effect of competition is that the firm's marginal revenue is greater and does not decline so

quickly as output increases. One consequence is that competitive firms produce more output at lower prices than monopolists. This impact of competition on marginal revenue is mirrored in the firm's marginal revenue product of capital, which is correspondingly higher and more robust to output under competitive circumstances. In essence, the heightened threat of loss of business to rivals impels the ILEC facing competition to lower prices, to produce more, to improve the quality and range of services, to innovate, and to invest more in order to accomplish these goals. The result is that incentives for investment and production of output are greater under the pressures of a competitive environment, and predictably the firm invests more.[11]

Despite these basic economic principles, the ILECs contend that the "TELRIC" methodology adopted by the Federal Communications Commission (FCC) to determine the rates that CLECs pay for UNEs does not adequately compensate ILECs for their investments in assets that are long-lived and may be partially or wholly sunk.[12] Although the question of whether or not UNE pricing compensates ILECs for past sunk investments may be of interest in other contexts, it is not relevant to the ILECs' current or future investment incentives. And as to the relevant issue of current and future investment, TELRIC by its very definition allows the ILECs to recover their full economic costs, including a risk-adjusted cost of capital and forward-looking depreciation lives that reflect both technological and economic obsolescence. Thus, TELRIC provides ILECs with the same incentive to invest as participants in competitive markets.

[11] The only set of circumstances under which this comparison might be distorted by the CLECs' use of UNEs would be if CLECs' use of UNEs to serve their customers significantly affected the marginal revenue product or the productivity of the facilities used by the ILEC to serve its customers. We are aware of no evidence that this is the case.

[12] Reply Affidavit of Jerry A. Hausman, In the Matter of Implementation of Local Competition Provisions in the Telecommunications Act of 1996, CC-Docket No. 96-98 (May 30, 1996). For a critique of the foregoing, see R. Glenn Hubbard and William H. Lehr, "Capital Recovery Issues In TSLRIC Pricing: Response To Professor Jerry A. Hausman" (July 18, 1996), reply affidavit submitted *ex-parte* by AT&T to the FCC, In the Matter of Implementation of Local Competition Provisions in the Telecommunications Act of 1996, CC-Docket No. 96-98.

D. The Competitive Stimulus Hypothesis

In contrast, the *Competitive Stimulus Hypothesis* is fully consistent with economic theory and with the analysis that justified passage of the Telecommunications Act of 1996.[13] Policy makers correctly understood that promoting competition would expand the market for telecommunication services and would improve suppliers' incentives to operate efficiently and to serve consumer needs. The lower prices that come with competition stimulate consumer demand. Some of the growing demand will be captured by the ILEC and some of it will be captured by CLECs. In both cases, additional facilities investment will be required to service the demand. And critically, ILEC investment will be encouraged both to meet the growth in ILEC retail demand and to serve the growing demand for wholesale services from the CLECs. If access to UNEs encourages CLECs that would not otherwise exist to form, their non-UNE investments also constitute a net increase attributable to unbundling.

Nor is price the only dimension along which increased competition will benefit consumers. As they compete, both ILECs and CLECs will have the incentive to use quality of service improvements and innovation as competitive tools to protect their own market share and to lure customers away from their rivals. Because most of these improvements must be embodied in network infrastructure, competition provides an added spur to increased investment.

III. EMPIRICAL TEST AND RESULTS

This theoretical debate can be practically resolved at an empirical level. The two competing hypotheses make different predictions regarding the effect of UNE prices on ILEC investment and describe different mechanisms upon which their respective predictions are based. Using standard econometric methods widely used in the profession, it is possible to test these competing hypotheses.

[13] See, for example, First Report and Order ¶ 679.

Our empirical analysis proceeds in two stages that reflect both aspects of these differences. First, to distinguish between the competing predictions made by the two hypotheses, we conduct a reduced form analysis that investigates the relationship between ILEC investment and UNE prices. To the extent that this relationship is positive, *i.e.* if higher UNE prices are associated with greater ILEC investment, the *Investment Deterrence Hypothesis* is supported. To the extent that this relationship is negative, *i.e.*, lower UNE prices are associated with greater ILEC investment, the *Competitive Stimulus Hypothesis* is supported. As we describe in more detail below, we find statistically significant evidence that this relationship is negative and substantial, *i.e.*, the empirical evidence refutes the *Investment Deterrence Hypothesis* but is consistent with the *Competitive Stimulus Hypothesis*.

Having found confirmation of the *Competitive Stimulus Hypothesis*' prediction in the first stage, the second stage of our analysis tests directly the mechanism of the *Competitive Stimulus Hypothesis*. According to the *Competitive Stimulus Hypothesis*, lower UNE prices leads to greater CLEC activity, and greater CLEC activity leads to greater ILEC investment. We therefore, use a structural equation approach in which we estimate the effect of UNE prices on CLEC activity and the effect of CLEC activity on ILEC investment. A negative relationship between UNE prices and CLEC activity and a positive relationship between CLEC activity and ILEC investment support the mechanism of the *Competitive Stimulus Hypothesis*. As we discuss further below, this is exactly the pattern found by our empirical analysis.

Finally, to further enhance our confidence in the results we conducted a number of additional sensitivity analyses and specification tests to assure ourselves that our results are valid. Specifically, we have carried out a test, described in more detail below, to confirm the appropriateness of the statistical technique we use to estimate the structural relationships. Additionally, we have gathered data on UNE prices from alternative sources and confirmed that our results are not dependent on the idiosyncrasies of one particular data source. Similarly, since we must control for the effect of varying levels of economic activity while estimating the effect of UNE prices on investment, we

have confirmed that our results are not dependent on our use of a particular measure of that activity. These sensitivity analyses are described in more detail below.

In summary, therefore, we conclude that the data on ILEC investment and CLEC activity since 1996 strongly refute the *Investment Deterrence Hypothesis*, and instead support the contrary – more theoretically consistent – *Competitive Stimulus Hypothesis*. In the following sub-sections we explain both regression approaches, describe the data, and present the results from our analyses.

A. Specification Of The Reduced-Form Regression

The first analysis we present of the relationship between UNE prices and ILEC investment is based on a reduced-form specification of the determinants of ILEC investment. A reduced-form specification is one that is derived from a more complex set of simultaneously interacting relationships. In a reduced-form specification, interactions between variables that exert mutual effects on one another are pushed into the background and the relationship to be estimated is a straightforward one between predetermined independent (or "exogenous") variables and a single dependent (or "endogenous") variable. By contrast, structural-form relationships embody the interactions between endogenous and exogenous variables explicitly, have meaningful behavioral interpretations, and generally must be viewed as a system of relationships. Their interaction, however, is more complex. Reduced-form relationships are simpler because a variety of behavioral relationships have been subsumed into them.[14]

[14] For example, in the standard economic model of a competitive market, the quantity demanded of a good is determined by its price, the levels and distribution of income of its consumers, the prices of substitute and complementary goods, and parameters that reflect tastes. Likewise, the quantity supplied of a good is determined by its price, the prices of goods and services used to produce the good, and parameters describing the technology for producing the good. In the marketplace, the price of the good is determined by simultaneous operation of the demand relationship, the supply relationship, and the equilibrium condition that the quantity demanded should be equal to the quantity supplied. In this model the demand relationship and the supply relationship interact simultaneously to determine two variables, *i.e.*, the quantity of the good changing hands in the market and the market price. The values of these two "endogenous" variables are simultaneously determined by the demand and supply relationships and the values of the predetermined or exogenous variables such as income, prices of substitutes and complements, taste parameters, prices of factors of production, and technology parameters. If one knew the demand and supply relationships, one could use them to calculate the market equilibrium price as a function of the

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In the analysis developed here, the reduced-form relationship is between ILEC investment as the dependent variable, and a group of exogenous variables that influence ILEC investment either directly or indirectly through their effects on CLEC activity. The reduced-form relationship takes the form

$$\begin{pmatrix} ILEC \\ Investment \end{pmatrix} = R\begin{pmatrix} Demand \\ Factors \end{pmatrix}, \begin{pmatrix} Current \\ Revenue \end{pmatrix}, \begin{pmatrix} ILEC\,Cost\,of \\ Investment \end{pmatrix}, \begin{pmatrix} CLEC\,Cost\,of \\ Participation \end{pmatrix}, \begin{pmatrix} Regulatory \\ Regime \end{pmatrix}.$$

The Demand Factors, ILEC Cost of Investment, and Regulatory Regime variables are included to control for the effects of other factors on ILEC investment decisions – that is, factors not associated with UNE-based unbundling requirements. Demand factors and the level of current revenue (an indication of current market prices) are included because they may be expected to affect ILEC investment directly, inasmuch as increased demand or higher prices should be expected to encourage investment, and indirectly, because they may have the same effect on CLEC activity. The cost to an ILEC of its own investment should certainly influence the level of ILEC investment. Variables relevant to describing the nature of the regulatory regime are also included because the character of regulation may be expected to have an effect on ILEC investment.

The CLEC Cost-of-Participation variable is the variable whose coefficient provides the basis for distinguishing between the two competing hypotheses. According to the *Investment Deterrence Hypothesis*, increases in UNE prices, which increase the cost of CLEC participation via unbundled network elements, should increase ILEC investment. That is, higher UNE prices render UNE-based entry less economically viable for CLECs, thereby alleviating the risk of alleged "free-riding" by CLECs. According to the *Investment Deterrence Hypothesis*, this should increase the ILEC's incentive to invest. In contrast, the *Competitive Stimulus Hypothesis* predicts that higher UNE prices will reduce ILEC investment because less economically-viable network element

(. . . continued)
exogenous variables. The resulting relationship is called a "reduced form," because the simultaneous interaction of multiple relationships and variables has been reduced to a single relationship between the endogenous dependent variable and the exogenous independent variables.

unbundling reduces CLEC competitive activity and the positive spur that such activity would otherwise provide for ILEC investment.

Thus, empirically one may distinguish between these two hypotheses by examining the signs and the levels of statistical significance of the estimated coefficients on the CLEC Cost-of-participation variables.

B. Specification Of The Structural-Form Regressions

In order to test directly the *Competitive Stimulus Hypothesis*, we use a structural approach. The *Competitive Stimulus Hypothesis* does not merely predict the negative relationship between UNE pricing and ILEC investment confirmed in the previous section. That prediction is based on further empirically testable predictions that the level of CLEC competition will be negatively related to UNE pricing and that the level of ILEC investment will be positively related to the level of CLEC competitive activity. Thus, according to the full economic structure of the *Competitive Stimulus Hypothesis*, it is the combination of these two effects that gives rise to the overall negative relationship observed between ILEC investment and UNE pricing.

In order empirically to investigate these two effects, we employ a specification that looks beyond the summary relationships embodied in the reduced-form model of Section II. This specification involves a system of two equations. The first,

$$\begin{pmatrix} ILEC \\ Investment \end{pmatrix} = f\begin{pmatrix} Demand \\ Factors \end{pmatrix}, \begin{pmatrix} Current \\ Revenue \end{pmatrix}, \begin{pmatrix} ILEC\ Cost\ of \\ Investment \end{pmatrix}, \begin{pmatrix} Regulatory \\ Regime \end{pmatrix}, \begin{pmatrix} CLEC \\ Activity \end{pmatrix},$$

posits that ILEC investment is a function of demand factors, current revenue, the cost of investment to ILEC firms, the form of the regulatory regime, and the level of competitive activity by CLEC firms. This equation reflects direct determinants of the ILEC firms' behavior.

The second equation reflects the determinants of the behavior of CLEC firms. It takes the form

$$\begin{pmatrix} CLEC \\ Activity \end{pmatrix} = g\begin{pmatrix} Demand \\ Factors \end{pmatrix}, \begin{matrix} Current \\ Revenue \end{matrix}, \begin{matrix} CLEC\ Cost\ of \\ Participat\ ion \end{matrix}.$$

In this equation the cost of participation to a CLEC firm is measured by the UNE prices.

Taken together these two equations form a system that determines two endogenous variables, ILEC investment and CLEC activity as functions of the exogenous variables. In this system, support for the *Competitive Stimulus Hypothesis* would take the form of a finding that the CLEC Cost-of-Participation is negatively related to CLEC activity in the second equation and that the level of ILEC investment is positively related to the level of CLEC activity in the first.

C. Data

To test the econometric relationships among ILEC investment, CLEC activity, and UNE pricing, data were collected from a variety of sources. These data can be grouped into five categories: (1) ILEC investment; (2) measures of the cost of CLEC participation, including both UNE prices and total service resale (TSR) discounts; (3) ILEC cost of investment; (4) control variables for other exogenous effects; and (5) CLEC activity measures.

1. ILEC Investment

Data on regional Bell operating company ("RBOC") investment by state are provided in the "ARMIS" reports submitted to the FCC, which include data by state and by year for each of the RBOCs in Table 43-02 B6, "Summary of Investment and Accumulated Depreciation."[15] Gross investment is reported as "Telephone Plant Additions." "Net TPIS" is computed as "Total Plant in Service at end of year" minus "Accumulated Depreciation at end of year." From these data, a measure of the net capital

[15] The ARMIS reporting data are available on-line at http://www.fcc.gov/wcb/armis/db/. We excluded data on GTE, which is now part of Verizon, because of inconsistencies with other data sources used in the analysis. For example, GTE has different UNE rates than do BOCs operating in the same state. Therefore, the RBOCs included were SBC (including what used to be SNET); Qwest (formerly US West); Verizon (excluding GTE); and BellSouth.

at the end of each year is constructed as the difference between the Total Plant in Service (TPIS) and the Accumulated Depreciation at the end of the year.

Net investment, that is the *growth* in capital stock, may then be calculated as the difference in net capital from one year to another.[16] In an earlier analysis, we focused on the change in net capital, net TPIS, over the four year period from 1996 to 2000 to smooth out any year-to-year variations in measured investment that may arise from differences in accounting and economic conventions for measuring capital. Since that analysis was prepared, data for ILEC TPIS for 2001 have been made available and so we also compute the change in capital over the five-year period from 1996 to 2001 as an alternative measure for ILEC net investment. Additionally, both estimates are divided by state population in the year 2000 (or 2001).[17] Dividing by state population controls for differences in the level of ILEC investment due to differences in the size of a state.

These variables are referred to in the results tables as *Investment to 2000* and *Investment to 2001*, respectively. They refer to the change in net TPIS per capita of terminal year population from 1996 to 2000, or from 1996 to 2001, respectively.

2. CLEC Cost-of-Participation: UNE Prices and TSR Discounts

Our first measure of the cost of CLEC participation is the state-specific rate for the "platform" of UNEs (UNE-P) for the most dense zone (usually called Zone 1) in each of the states. Because UNE rates are set somewhat differently in each state and because UNE-P rates include both traffic-sensitive and non-traffic-sensitive elements as well as both recurring and non-recurring elements, it is not a simple matter to obtain an internally consistent set of estimates of UNE-P rates by state. There are a number of sets of

[16] Economists distinguish between the *stock* of capital that exists at any point in time, and the *flow* of investment, which is net additions to capital. In some contexts, non-economists may misuse the term investment to refer to a stock of capital. Throughout this paper, we use investment only to refer to flows.

[17] The data on state population is for state-wide population from the 2000 Census. The statewide population for 2001 (and for other years when needed) is estimated by extrapolation, using the growth in statewide population between the 1990 and 2000 Census. Data on statewide population for the 1990 and 2000 Census are available on-line from the http://www.census.gov.

estimates available from various sources, and in our analysis we make use of estimates from a variety of sources.

We have primarily relied on data compiled by AT&T for their internal use. These data provide state-by-state estimates of current UNE-P rates for all of the lower 48 states. In an earlier analysis that was prepared in March 2002, the only UNE-P data available covered a smaller sample of states. Our current sample, calculated as of the end of June 2002, significantly increases the number of covered states. Earlier versions of the data were incomplete and did not include estimates of all of the rate elements that a CLEC would pay if it sought to make use of UNE-P services. The more recent June data were augmented and checked to ensure that UNE-P rates were computed on a comparable basis for each state.

We have located additional estimates of UNE price data from three different sources: Regulatory Research Associates TeleFOCUS estimates from August 2000; the National Regulatory Research Institute's estimates from Spring 2001 and July 2002; and the loop proxy rates set by the FCC in its August 1996 First Report and Order.

Regulatory Research Associates (RRA) is a market research firm that tracks developments in telecommunications policy and that publishes a series of proprietary reports to which AT&T and other participants in the industry subscribe. In August 2000, RRA published a special industry report, *Unbundled Network Elements: An RBOC Rate and Policy Analysis*,[18] that provided state-by-state estimates of UNE rates for different elements used to construct UNE-P services. National Regulatory Research Institute (NRRI) likewise publishes estimates of UNE rates from the spring of 2001 and for July 2002.[19]

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[18] See *Unbundled Network Elements: An RBOC Rate and Policy Analysis*, TeleFOCUS, Special Industry Report, Regulatory Research Associates (August 11, 2000).

[19] The data for spring 2001 are from a paper prepared by Billy Jack Gregg, "A Survey of Unbundled Network Element Prices in the United States" (Spring 2001). Mr Gregg is the Director of the Consumer Advocate Division of the Public Service Commission of West Virginia. The data for July 2002 are from an updated version of Mr. Gregg's report. Both are available from the NRRI website at http://www.nrri.ohio-state.edu/programs/telcom/.

Both of these alternative sources of data, however, suffer from several disadvantages. First, it is not possible to use these data alone to estimate UNE-P prices, since traffic data are also required in order to estimate the cost of usage-sensitive elements. Second, these data do not include estimates of non-recurring charges. In the case of the NRRI data, Mr. Gregg attempted to address the problem of estimating usage sensitive rate components by assuming a constant 1000 minutes of use per line per month. This is not a reasonable assumption, however, as becomes apparent if one examines the NECA-reported data on minutes of use by state. These data show that usage varies significantly, both by state and over time.

To address these deficiencies in the data, we considered including the individual rate elements in our analysis. We rejected this approach because it would provide only a very noisy indicator of the UNE-P rates faced by CLECs. Moreover, unless properly weighted there was a chance we would obscure systematic biases that may exist in the data, *e.g.,* where higher loop rates were offset by lower rates for other elements. Including multiple rate elements simultaneously would not be appropriate either, because there would be no clear basis for interpreting the results and the number of variables that could be meaningfully included as explanatory variables in the regressions is limited by the size of our sample (48 states).

Furthermore, we were not able to verify the accuracy of the data reported in these sources. In the case of the RRA TeleFOCUS data from August 2000, this was complicated by the fact that RRA disbanded the TeleFOCUS group in June 2002. Nevertheless, a spot check suggests that the report contained errors (*e.g.,* the switching charge for Michigan was an order of magnitude too high).[20]

The third source of data we considered was from the FCC's First Report and Order,[21] which provided proxy ceiling rates for UNE loops. Unfortunately, as with the

[20] After several calls to the Michigan Public Service Commission we were able to verify that the charge for switching per originating or terminating Minute of Use was $0.003164 not $0.03164 as reported in the TeleFOCUS report. We were not able to verify the other estimates in the report but an error of this magnitude raises substantial concerns as to the accuracy of the entire report.

[21] See FCC First Report and Order ¶¶ 788-827 & App. D.

other sources, we did not have a way to compute from loop-only data the appropriate UNE-P rates, which is the preferred measurement for our purposes.[22]

On balance we believe that the data provided by AT&T are the best estimates available to us of UNE prices by state. We recognize, however, that no data set is perfect and that each of the available data sets may embody some useful information. We have, therefore, employed procedures, described below, that seek to make use of all the information contained in the various data sets available to us.

The total service resale option offers an alternative means for a CLEC to enter the market. Hence, we include data on TSR discounts provided by AT&T.[23] Because these are discounts, a higher discount means a lower cost of entry and, so, should have the same directional effect, *ceteris paribus*, on ILEC investment and CLEC activity as a lower UNE rate.

3. ILEC Cost of Investment

The ILEC Cost of Investment is measured by TELRIC costs as estimated by the FCC's Synthesis Model.[24] We use the access-line-weighted state average across all switched access lines for all density zones. TELRIC costs are available for all of the lower 48 states. Since our sample is a cross section, there is no variation in the financial cost of capital over time with which we need to be concerned. As long as variations in the nation-wide cost of capital do not affect TELRIC costs differentially in different

[22] The ceiling rates for other elements were not broken down by state.

[23] Because the focus of the analysis is on UNE rates and TSR data is less controversial, we did not include alternative estimates of the TSR discount from different time periods.

[24] More specifically, the TELRIC estimate of the cost of the network platform (UNE-P) is derived from the FCC's Synthesis Model, adjusted to yield total switched local network costs. This model estimates the TELRIC for providing local telephone and access services. It includes a return for invested capital and an allowance for general overhead costs. See Fifth Report and Order, In the Matter of Federal-Joint Board on Universal Service, CC-Docket No. 96-45 and Forward Looking Mechanism for High Cost Support for Non-Rural LECs, CC-Docket No. 97-160 (October 28, 1998). The model may be obtained from the FCC's website at http://www.fcc.gov/ccb/apd/hcpm/. The adjustments to the model to include costs for providing intraLATA toll and access services are explained in Ex Parte Presentation by AT&T to Federal Communications Commission, In the Matter of Application by Verizon New England, Inc. Bell Atlantic Communications, NYNEX Long Distance Company, and Verizon Global Networks to Provide In-Region InterLATA Services in Massachusetts, CC Docket No. 01-9 (February 1, 2001).

states, the TELRIC costs serve as a reliable index of cross-section variation in the ILEC Cost of Investment over the entire period for which we measure ILEC investment. *Ceteris paribus*, one should expect that higher TELRIC costs would result in reduced ILEC investment (*i.e.,* the coefficient on TELRIC ought to be negative).

4. Control Variables for Other Exogenous Effects

In addition to UNE rates and the level of CLEC activity, there are a number of other factors that might reasonably be expected to influence both the level of ILEC investment and CLEC participation. We included a number of additional variables to control for these other influences.

First, to control for the effect of the level of telephone prices in the state, we included Average Revenue*,* which is a measure of the average revenue collected per residential line in the state.[25] Our measure of average revenue includes access fees, Subscriber Line Charges and charges for vertical features such as call waiting, call forwarding, and caller-ID. *Ceteris paribus*, one might expect that higher retail prices would result in both higher ILEC investment and higher CLEC participation by state (*i.e.,* the coefficients on Average Revenue should be positive).

Second, to control for other demographic and economic features of each state that may affect either the demand for, or the cost of, providing telecommunication services in the state (which in turn, might be expected to affect the level of infrastructure investment), we included three demographic variables. The first, Labor Force Share in FIRE*,* is the share of the labor force employed in three telecommunications intensive industries, Finance, Investment, and Real Estate (FIRE), in 2000.[26] The second, Population Growth*,* is the percentage growth in statewide population from the 1990

[25] These data were provided by AT&T and are based on the state's residential line distribution by density zone, tariffed local service rates, TNS Telecoms Bill Harvesting Study: 1Q01-3Q01 for features, local minutes of use drawn from ARMIS business and residential data, and toll-related minutes of use drawn from TNS Telecoms Bill Harvest research.

[26] The data on employment composition by state are from the 2000 Census as reported in the State Annual Tables that report State Economic Profiles (SA-3) which are produced by the Bureau of Economic Analysis of the U.S. Department of Commerce (September 2001). These data are available at http://www.census.gov.

Census to the 2000 Census.[27] The third, Average Unemployment, is the average rate of unemployment in the state from 1996 to 2000.[28] The demand for telecommunications services, and, hence the demand for investment in telecommunications infrastructure, should be greater in states where the relative importance of telecommunications intensive industries is greater, in states with faster population growth, and in states with more robust economies, as measured by lower unemployment. Therefore, one might expect a positive relationship between Labor Force Share in FIRE and ILEC investment and CLEC participation and between Population Growth and ILEC investment, and a negative relationship between Average Unemployment and ILEC investment.[29]

Third, to control for other differences (*i.e.,* those that are not related to UNE unbundling or total service resale discounts) in the form of state regulation, we include a collection of variables to control for the nature of the regulatory regime as it pertains to the major ILEC in each state. The data for these variables come from a report by the National Regulatory Research Institute.[30] This report characterizes the regulatory regime in each state as of October 2000 in one of five categories: 1) Rate of Return Regulation, 2) Price Cap Regulation, 3) Price Cap/Interim Rate Freeze, 4) Rate Freeze Non-indexed Caps, and 5) Deregulation. For purposes of estimation we have assigned each state the regulatory form applicable to residential service provided by the major ILEC, and have constructed five indicator variables, one for each form. The indicator variables, commonly called dummy variables, take on the value 1 in each state where that regulatory form prevails, and are zero elsewhere. All but one of the dummy variables,

[27] The data on state population is for state-wide population from the 2000 Census. The statewide population for 2001 (and for other years when needed) is estimated by extrapolation, using the growth in statewide population between the 1990 and 2000 Census. Data on statewide population for the 1990 and 2000 Census are available on-line from the http://www.census.gov.

[28] The data on the average unemployment by state are available from the Bureau of Labor Statistics for each year from 1996 through 2000. This data is available on-line at http://www.bls.gov. There was no unemployment data for Michigan for 1998 through 2000.

[29] We experimented with other proxies for the intensity of telecommunications demand such as per capita income, percentage of non-farm income, and per capita gross state product. Use of these alternative proxies did not substantively change the results reported here.

[30] The source of the data is from a table "Forms of Regulation for Basic Service in the U.S. States," from the State Telephone Regulation White Paper, National Regulatory Research Institute, as of October 2000.

the variable for rate of return regulation, are included in the regression. For technical reasons, one dummy variable from a mutually exclusive and exhaustive set such as these must be omitted. This technical omission does not neglect any impact that this form of regulation might have, since the estimates pertaining to each of the included variables measures the effect of that variable relative to the effect of the omitted variable -- *e.g.,* the estimated effect of the Price Cap regulation variable measures the effect of Price Cap regulation relative to Rate of Return regulation.

Fourth, we include 1996 Plant in Service per capita to control for the infrastructure that was in place in each state as of 1996. This is the net TPIS by state from the ARMIS data used to compute our measure of the level of ILEC investment, described above.

5. CLEC Activity Measures

In addition to the variables described above, our structural equation approach requires a measure of CLEC activity. To measure the extent of CLEC activity, we used two measures. The first measure is the number of CLECs that were registered or licensed to operate in each state as of June 2001. These data are available for each state from the FCC.[31] The natural logarithm of the number of CLEC firms in each state was used instead of the absolute number of firms. In the results, this variable is identified as the Log of Number of CLECs.

In addition to considering this variable, we also introduced as an alternative measure of CLEC activity the share of zip codes in each state that are served by one or more CLECs as of June 2001, as reported to the FCC.[32] This variable is identified in the results as the Share of Zip Codes w/ CLEC.

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[31] See Table 8 of *Local Telephone Competition: Status as of June 30, 2001*, Industry Analysis Division, Common Carrier Bureau, Federal Communications Commission (February 2002).

[32] See Table 13 of *Local Telephone Competition: Status as of June 30, 2001*, Industry Analysis Division, Common Carrier Bureau, Federal Communications Commission (February 2002). Percentage with one or more is computed as one minus the percentage with zero.

We also investigated the possibility of using data on the number of CLEC lines served by state, but we were unable to obtain a data source that was consistent with the other sources of data and that was reasonably complete. Because of changes in the FCC's reporting requirements and because of the fact that the FCC withholds data for states where competition is so limited that reporting the number of lines would be deemed to reveal competitively sensitive information, the data on CLEC lines by state did not provide a useful measure of CLEC activity for the study. Reliance on such data would have resulted in an unacceptable reduction in the size of our sample, and would have biased our results.

D. Reduced-Form Analysis Results

The results of estimating the reduced form are shown in Exhibit 1. Exhibit 1 shows the results of estimating two versions of the reduced-form model described above, one in which the dependent variable for ILEC investment is Investment to 2000 (*i.e.*, per capita change in net TPIS from 1996 to 2000), and one in which the dependent variable for ILEC investment is Investment to 2001 (*i.e.,* per capita change in net TPIS from 1996 to 2001). These models are estimated for each set of UNE price data. The results of the two regressions using the AT&T UNE price data are shown in the second and third columns on the first page of the exhibit and are described in the first column. For each independent variable listed in the first column, the second two columns show the estimated coefficient for that variable with the standard error of the estimate in parentheses immediately below.

The estimated coefficient is the estimated value of the effect of a change in the independent variable on the value of the dependent variable. If an estimated coefficient is positive, increases in the independent variable are estimated to cause the dependent variable to increase. The size of the coefficient is the estimated rate of increase. If the estimated coefficient is negative, then increases in the independent variable are estimated to cause the dependent variable to decrease. The standard error of the estimate is a measure of how precisely the coefficient has been estimated. The smaller the standard error, the more precise the estimate and vice versa.

Using the standard error and other information about the regression such as the number of observations and the number of variables included in the regression, a calculation may be made to determine whether or not the estimated coefficient is statistically significant.[33] In Exhibit 1, all the coefficients that are statistically significant at the 95% level are marked with a single asterisk (*); all the coefficients that are statistically significant at the 99% level are marked with a double asterisk (**).

[33] The assessment of an estimated coefficient's statistical significance is important because statistical methods generally do not permit an unknown parameter to be measured or determined exactly. Statistical estimates of unknown parameters are subject to some degree of random error, so when an estimate such as a regression coefficient is calculated some method is needed to inform a judgment as to whether or not the result of the calculation is a meaningful finding or merely the result of random error. The test of statistical significance provides a means of making such a judgment.

Consider, for example, the estimated coefficient of approximately 173.6 on population growth reported in the second column of Exhibit 1. Because this estimate is positive it means that the estimated effect of population growth on ILEC investment is positive. In other words, all other things constant, a state whose population grows faster is estimated to experience greater ILEC investment. To determine whether or not this figure is meaningful, statisticians exploit the fact that the probability distribution of the ratio of this estimate to its standard error, a ratio that is known as a t-statistic, may be calculated. That means it is possible to calculate the probability that an estimated coefficient as large as 173.6 could have been obtained if, in fact, the true (but still unknown) coefficient were zero, *i.e.*, if there were no relationship between population growth and ILEC investment in fact. If the probability of obtaining such a large estimate relative to its standard error is very small, then the observed estimate probably does not reflect the workings of random error and probably does reflect a systematic relationship. In this case, the estimate is statistically significant. On the other hand, if the probability of obtaining an estimated coefficient that large or larger is high when the true coefficient is zero, then one can not rule out randomness as an explanation for the estimate, in which case the estimated coefficient is statistically insignificant.

The test of statistical significance is an example of a statistical hypothesis test. To carry out a statistical hypothesis test, one specifies the hypothesis to be tested (called the null hypothesis). In this example, we test the hypothesis that the true coefficient governing the effect of population growth on ILEC investment is zero – in other words we test the hypothesis that there is no systematic relationship between population growth and ILEC investment. Then, a test statistic whose probability distribution is known and which may be counted on to behave one way if the hypothesis to be tested is true and to behave another way if it is not true is calculated. The value of the test statistic is observed and the probability of obtaining that value if the null hypothesis is true is calculated. If that value is small, say 5% or less, then the null hypothesis is rejected. The complement of the threshold probability for rejecting the null hypothesis is called the confidence level of the test. If the null hypothesis is rejected when the probability of the test statistic is 5% or less, one describes the confidence level of the test as 95%. A more demanding test would only reject the null hypothesis if the probability of the test statistic were 1% or less. In this case, the confidence level is 99%.

An estimated regression coefficient is statistically significant if the null hypothesis that the true coefficient is zero is rejected. The coefficient is significant at the 95% level if the null hypothesis of a zero value is rejected because the probability of the test statistic is 5% or less. The coefficient is significant at the 99% level if the null hypothesis of a zero value is rejected because the probability of the test statistic is 1% or less.

The results in the second column on the first page of Exhibit 1 show that the estimated coefficients on the share of the labor force in finance, investment and real estate, the growth in population, and the average revenue earned by telephone companies are positive and statistically significant. In other words, the regression finds evidence that can not be attributed to mere chance that ILEC investment is greater, all other things constant, in states with a larger share of the labor force employed in finance, real estate and investment, in states whose populations grow faster, and in states whose regulators allow telephone companies to earn greater revenues. These findings are all consistent with the predictions of economic theory for this relationship. Likewise, the estimated coefficient on the TELRIC cost variable is negative and statistically significant. This too comports with economic theory, since TELRIC measures the cost of investment goods to the ILEC.

Very similar results appear in the third column, indicating that for the most part the results are not sensitive to whether ILEC investment is measured to 2000 or to 2001. Except for the share of the labor force in telecommunications intensive industries, the same coefficients are statistically significant in the second regression as were in the first, and they all have the same sign in the second regression as they had in the first.

Following the estimated coefficients and their associated standard errors is a set of summary statistics for the regression as a whole. The first is the number of observations in the sample.[34] The second is the *F*-statistic, which is used to test the statistical significance of the estimated relationship as a whole.[35] The R^2 statistic measures the proportion of the variation in the dependent variable for which the estimated relationship can account. The adjusted R^2 makes a similar measurement, adjusted for the number of

[34] The estimates shown on the first page of Exhibit 1 are based on a sample of 47 observations. For most of our variables we have observations for all of the lower 48 states, but the unemployment figures for Michigan are missing from the government data. When we approximate the missing value of Michigan's unemployment rate, we obtain similar results.

[35] The *F*-statistic is used to test the null hypothesis that there is no systematic relationship between the dependent variable and any of independent variables considered collectively (in other words, to test the hypothesis that the true values of all the coefficients are zero). The more evidence there is of a systematic relationship, the larger the *F*-statistic. If the *F*-statistic is so large that the null hypothesis of no relationship may be rejected, the regression as a whole is statistically significant.

independent variables included and the number of observations employed. The results shown in the second column indicate that the model does a good job of accounting for variation across states in ILEC investment, as measured in per capita terms, both between 1996 and 2000 and between 1996 and 2001. The regressions account for over 77% of the variation in the investment variable (just under 70% on an adjusted basis), and, as indicated by the double asterisks shown near the bottom of the page, each regression as a whole is statistically significant at the 99% confidence level.

In short, using the AT&T UNE price data these regressions explain a large share of the variation in the dependent variable, *i.e.*, ILEC investment, and are statistically significant at a high level, 99%. In both cases, the estimated effects of independent variables on the dependent variables include statistically significant estimates that are consistent with the underlying economic theory. Thus, these regressions provide a good context within which to examine the effect of UNE prices on ILEC investment. Moreover, in both cases the estimated coefficient on the UNE price is negative and statistically significant. This means that after taking into account all the factors accounted for by other independent variables in the regression, higher UNE prices discourage ILEC investment. Thus, the results provide strong support for the *Competitive Stimulus Hypothesis*, and reject the *Investment Deterrence Hypothesis*.

The numerical magnitude of the investment-stimulating effect of unbundling may be calculated from the estimated regression results. In Exhibit 1 the estimated coefficient on the UNE price variable provides an estimate of the effect on net investment per-capita of terminal year population per $1 increase in the zone-1 rate for UNE platform service. By combining that estimated coefficient with the mean values in our sample of the UNE price variable and the ILEC investment variable, that estimated coefficient may be used to calculate an estimated elasticity, *i.e.,* a calculation of the effect of changes in UNE prices on ILEC investment that is expressed in percentage terms. Using the estimate from the regression reported in the second column of the first page of Exhibit 1, where ILEC investment is measured to 2000, the estimated elasticity is -2.89; using the estimate from the regression reported in the third column of the first page, where ILEC investment is measured to 2001, the estimated elasticity is -2.10. An elasticity of -2.10 means that if

UNE prices were increased by 1%, the regression results estimate that ILEC investment would decline by 2.1%.

The subsequent pages of Exhibit 1 report regression results using UNE price data from other sources. The results we obtain using either set of data from NRRI or either set of data from Telefocus show a similar pattern. Comparing these results with those obtained using the AT&T UNE prices, we see some elements of consistency and some differences. The results are consistent in that the same variables whose coefficients were statistically significant using the AT&T data are often significant with these other four sets of data. We also see no statistically significant coefficients using these four sets of data that reverse the sign of a significant coefficient obtained using the AT&T data. The results are different in that the quality of the fit with the other four data sets is modestly smaller than with the AT&T data, and with both the NRRI data and the Telefocus data the estimated coefficient on the UNE prices is not statistically significantly different from zero.

This pattern is consistent with, and indeed tends to confirm, our reservations about the these data sets. When regression data are prone to error, regression estimates are less precise. Statistical significance is hard to achieve and the overall fit tends to be lower. The pattern we see in this comparison suggests that the NRRI and Telefocus UNE price data are noisier, and, therefore, less informative, than the AT&T data.

The results shown on the last page of Exhibit 1 were obtained using the FCC proxy ceiling rates from the First Report and Order. These results are strikingly similar to the results obtained with the AT&T data. The estimated coefficients for population growth, average revenue, and the dummy variable associated with deregulation are all statistically significant and have the expected signs. The share of variation in the dependent variable for which the regression can account is high; in this case over 80% and over 70% on an adjusted basis. The regression equations are statistically significant at the 99% confidence level as well.

Using the FCC proxy ceiling rates both of the UNE price coefficients reported on the last page of Exhibit 1 are negative and statistically significant at the 99% confidence

level. In other words, these regressions also provide a strong refutation of the *Investment Deterrence Hypothesis* and strong support for the *Competitive Stimulus Hypothesis*. Moreover, taken together the results on the first and last pages of Exhibit 1 show that this conclusion is not dependent on the point in time at which UNE prices were estimated. The two sets of data that measured UNE prices with sufficient precision to yield statistically meaningful results on the relationship between UNE prices and ILEC investment represent respectively the latest and earliest estimates of UNE prices among the six sets of data available to us. The AT&T UNE prices were calculated as of June 2002, and the FCC ceiling proxies date from the First Report and Order, which was issued in August of 1996.

Even the AT&T data, which we believe are the most reliable, are nonetheless estimates, and as such may contain some errors. Generally errors in a variable tend to make it harder to obtain statistically significant results, such as those shown on the first and last page of Exhibit 1, so the prospect of such errors does little to undermine our confidence in the results we have already described. When errors are suspected in an independent regression variable, an alternative estimation technique known as "instrumental variable regression" is often employed to overcome the difficulties created by the suspected errors. The instrumental variable technique makes use, if they can be found, of additional variables, called instruments, that are correlated with the correct values of the variable that is measured with error, but are uncorrelated with the errors.

In our case, where we want to consider the possibility that the AT&T estimates of UNE prices may contain errors and five additional sets of estimates are also available, the additional estimates are natural instruments. They should be correlated with the correct value, since each is a measurement of the same phenomenon, but since the other sets of data were compiled at different times by different individuals and using, possibly, different methods, their errors should be uncorrelated with whatever errors may be present in the AT&T estimates.

Exhibit 2 reports the results obtained by employing instrumental variable regression. To calculate the results shown in Exhibit 2 we have used the AT&T estimates

of UNE prices as an independent variable, but have employed the NRRI, Telefocus, and FCC proxy UNE prices as instruments. The results shown in Exhibit 2 are very consistent with those obtained using the AT&T data in Exhibit 1. The estimated coefficients on population growth, average revenue, and the deregulation variable are all statistically significant at the 99% level. The estimated coefficient on the TELRIC variable is statistically significant at the 95% level, as is the share of the labor force in Finance, Real Estate, and Investment in one equation.[36] Each of these coefficients has the expected sign. The regressions explain over 75% of the variation in ILEC investment, nearly 70% on an adjusted basis, and are statistically significant at the 99% level.

In both of these regressions the estimated coefficient on the UNE price is negative and statistically significant. Thus, when we allow for the possibility that the AT&T UNE price estimates may contain some errors, the empirical results still refute the *Investment Deterrence Hypothesis* and support the *Competitive Stimulus Hypothesis*.

E. Structural-Form Analysis Results

The results of estimating the structural-form equations are shown in Exhibits 3 and 6. Exhibit 3 shows the results of estimating the structural version of the ILEC investment equation and Exhibit 6 shows the results of estimating the CLEC activity equation. As in Exhibit 1, the ILEC investment equation is estimated once using a variable that measures ILEC investment from 1996 through 2000 and again using a variable that measures ILEC investment from 1996 through 2001. CLEC activity is measured using the logarithm of the number of CLEC firms or the share of zip codes in the state with one or more active CLECs.

The results in Exhibits 3 and 6 are estimated using ordinary least squares (OLS). Because it is a recursive system free of simultaneous equation bias, OLS is an appropriate

[36] In the other regression, the coefficient on the labor force share in FIRE is statistically significant at the 93% level.

technique to use for these structural equations.[37] Exhibit 3 displays regression results in a format that is similar to Exhibit 1. The summary statistics show that all four variations on this equation account for close to 75% of the variation in ILEC investment. Similarly, all four regressions are statistically significant at the 99% confidence level. Among the independent variables, population growth, telephone company average revenue, and TELRIC are statistically significant and have the signs predicted by economic theory in all four variations. Because the ILEC investment structural-form equation does not include the UNE price, there is no need to calculate different estimates for each version of the available UNE price data.

Exhibit 3 also confirms the first leg of the mechanics of the *Competitive Stimulus Hypothesis*. The coefficients on the CLEC variables are all positive, and they are statistically significant at the 95% confidence level or better in three out of the four variations. The fourth variation is statistically significant at the 94% confidence level.

Exhibit 4 presents the results of a statistical test for simultaneous equations bias, which, if present, would indicate that OLS was an inappropriate estimation technique for the regressions shown in Exhibit 3. The calculation of the test statistic depends on an estimate of the CLEC activity equation. Because that equation does include the UNE price as dependent variable, the calculation of the test statistic depends on which set of UNE price estimates is assumed to provide the best measure of UNE prices. Exhibit 4 shows the values of the test statistic for each regression shown in Exhibit 3 with varying assumptions as to which set of UNE price estimates are best. If the value of the statistic

[37] Often in econometrics the structural equations in a multiple equation model cannot be estimated with OLS without bias. Under certain circumstances the bias arises from the presence of multiple endogenous variables in the specification of the equation. When OLS is biased, econometricians need to use different techniques, such as instrumental variable regressions, to estimate structural equations without bias. However, this kind of simultaneous-equations bias is not present when OLS is used to estimate this model for two reasons. First, the CLEC activity equation only includes one endogenous variable, *i.e.,* the level of CLEC activity. Therefore, that equation may be estimated using OLS without any simultaneous equations bias. Second, other than the dependent variable (ILEC investment) the only endogenous variable in the ILEC investment equation is the CLEC activity variable. That means this system of equations is a recursive system, a type of system that can be estimated using OLS without simultaneous equations bias. See G.S. Maddala, *Econometrics* (McGraw-Hill, 1977), at 250 and Robert S. Pindyck and Daniel L. Rubinfeld, *Econometric Models and Economic Forecasts*, 3rd Ed. (McGraw-Hill, 1991), at 298.

is statistically significant, which is indicated by the presence of an *, OLS is an inappropriate means of estimating the regression shown in Exhibit 3.

In most cases the test statistics shown in Exhibit 4 do not indicate the presence of simultaneity bias. Only when we assume that the FCC proxy ceilings are the best measure of UNE prices does the test indicate simultaneity bias. This indicates that when the FCC proxy ceilings are used to measure UNE prices, OLS should not be used to estimate the structural form ILEC investment equation. A procedure that overcomes simultaneity bias is instrumental variables regression. In this case, all the exogenous variables in both structural form equations are used as instruments for the CLEC activity variable in the ILEC investment equation.

The results of this estimation are shown in Exhibit 5. Because instrumental variables regression can be less efficient than ordinary least squares, the regressions shown in Exhibit 5 account for a smaller, although still substantial, share of variation in the dependent variable than those shown in Exhibit 3. The estimated regressions are statistically significant at the 99% confidence level and the statistically significant coefficients have the expected signs. When CLEC activity is measured by the share of zip codes, the estimated coefficient on the CLEC activity variable is positive and statistically significant at the 99% level. When CLEC activity is measured by the number of CLECs, the coefficient on the CLEC activity is positive and statistically significant at the 95% level when ILEC investment is measured to 2000, and is positive and statistically significant at the 94.9% level when ILEC investment is measured to 2001. Thus, when simultaneity bias is detected in the ordinary least squares estimates we are led to employ a different estimation technique, but reach the same conclusion, namely that our estimates of the ILEC structural equation support the mechanism of the *Competitive Stimulus Hypothesis*.[38]

[38] All the results in our exhibits are marked for statistical significance at the 95% and 99% confidence levels. At these confidence levels, the specification test statistics in Exhibit 4 that are calculated using the AT&T data are statistically insignificant. However, if the level of statistical significance were lowered to 90%, then the test statistics of 2.93 and 3.01 obtained using the AT&T UNE price data and the logarithm of the number of CLECS would be statistically significant, and we would infer that simultaneous equations bias is present in those OLS results. For these two cases where simultaneous equations bias is inferred at

(continued . . .)

Exhibit 6 shows the results of estimating the structural CLEC activity equation. As with the reduced form ILEC investment equation, one set of estimates is calculated for each set of UNE price data available. CLEC activity is measured somewhat imperfectly, because of the fact that two different proxy measures are being tested. Thus, it is not surprising that the CLEC equation accounts for a smaller share of the variation. Still, using the AT&T UNE price data the CLEC equation is statistically significant at the 99% confidence level when CLEC activity is measured by the number of firms and at the 95% level when CLEC activity is measured by the share of zip codes with a CLEC. Additionally, the estimates calculated using the AT&T data provide support for the second leg of the *Competitive Stimulus Hypothesis*. The estimated coefficient on the UNE price is negative and statistically significant at the 99% level in the first variation and at the 95% level in the second.[39]

As for our estimates of the reduced form ILEC equation, the estimates obtained with NRRI data and the estimates obtained with Telefocus data are less precise than those obtained with the AT&T data. For the most part, the estimated coefficients on the UNE price using these data are statistically insignificant. There are two exceptions. One is obtained using the NRRI data from 2001 and the other exception is obtained using the Telefocus data from zone 1. With both of these data sets when the level of CLEC activity

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the 90% confidence level we have calculated the instrumental variables estimates of the ILEC structural equation and found a positive relationship between ILEC investment and CLEC activity that is statistically significant at the 90% level in one case and at the 89.7% level in the other. Thus, we find that if the threshold level of statistical significance for drawing an inference is lowered from 95% to 90%, we are led to employ instrumental variables regression in two additional cases, but reach the same conclusion, namely that our estimates of the ILEC structural equation support the mechanism of the *Competitive Stimulus Hypothesis*.

[39] The regression reported in column 2 of Exhibit 6 are based on samples of 46 observations. The second column has 47. The observation for Michigan and Delaware are both missing in the second column, Michigan because no unemployment data are available and Delaware because the FCC data on the number CLECs identifies 0 CLECs in Delaware. Because as a matter of mathematics one cannot take the logarithm of zero, there is no value for this variable for Delaware. Delaware is included, however, in the third column. We understand, however, that there is a CLEC, (Cavalier Telephone Company) operating in Delaware that is not reflected in the FCC data. See www.cavtel.com. We have tested our results for robustness with respect to both of these omissions (Michigan and Delaware). As with the reduced-form model, when we add an approximate value for Michigan there is no substantive change in the results. Likewise, when we include Delaware in the sample with the data corrected to reflect the missing CLEC in Delaware, there is no substantive change in the results.

is measured using the logarithm of the number of CLECs, the estimated coefficient on the UNE price is negative, as predicted by the *Competitive Stimulus Hypothesis*, and statistically significant.

Once again we also find that the results obtained using the FCC proxy data are strong and consistent with those obtained using the AT&T data. In both of the last two columns of Exhibit 6, the estimated coefficient on the UNE price is negative and statistically significant at the 99% level, as are the regressions reported in those columns. Thus, these estimates provide support for the mechanism of the *Competitive Stimulus Hypothesis*. Additionally, the two sets of regression estimates calculated using FCC proxy data account for a larger share of the variation in their respective dependent variables than do the corresponding regressions calculated with the other sets of data.

Exhibit 7 is analogous to Exhibit 2. In Exhibit 7, we report the results of estimating the CLEC activity equation using the NRRI data, the Telefocus data, and the FCC proxy data, as instruments for the AT&T data to allow for the possibility that the latter are measured with error. When we measure CLEC activity by the logarithm of the number of CLECs, the estimated relationship between CLEC activity and the UNE price is negative and statistically significant at the 99% level. If CLEC activity is measured using the share of zip codes with a CLEC, the estimated coefficient is negative and statistically significant at the 94% level. Thus, these estimates provide further support for the mechanism of the *Competitive Stimulus Hypothesis*.

IV. RESPONSE TO CRITIQUES

The earlier version of this analysis that was included in a filing to the FCC by Professor Willig reached similar conclusions but was based on a less complete data set.[40] In response, affiants for several of the ILECs filed reply comments that criticized those results. These included comments from Timothy Tardiff,[41] John Haring *et al*.,[42] the

[40] See *Declaration of Robert D. Willig on Behalf of AT&T*, In the Matter of Review of the Section 251 Unbundling Obligations of Incumbent Local Exchange Carriers, CC Docket No. 01-338 (April 2002).

[41] *An Appraisal of Professor Willig's Econometric Analysis, Exhibits 2 and 3 by Timothy J. Tardiff submitted on behalf of SBC*, as an appendix to Reply Affidavit of Alfred E. Kahn and Timothy J. Tardiff, In (continued . . .)

National Economic Research Associates,[43] Howard Ware,[44] and an unsigned statement submitted by BellSouth, SBC, and Verizon.[45] We have reviewed these comments, and in this section, we explain why none of them alters the conclusions presented above.

Before responding to specific critiques in greater detail, it is worth pointing out that none of the critics provide a basis for accepting the *Investment Deterrence Hypothesis*, *i.e.,* that the unbundling rules of the Act reduce ILEC investment. Instead, they have chosen to focus on attacking the alternative hypothesis, *i.e.*, that unbundling promotes investment by CLECs and ILECs alike.[46] The critiques come in a number of forms but may be grouped into five general categories: (1) temporal inconsistency; (2) omitted variables problems; (3) other specification problems (4) mis-measured variables; and (5) incorrect interpretation of regression results. We address -- and refute -- each of these in turn below.

A. Temporal Inconsistency

Several of the critics take exception to our use of UNE-P rates from June 2002 to explain CLEC activity as of June 2001 and ILEC investment behavior from 1996 through

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the Matter of Review of the Section 251 Unbundling Obligations of Incumbent Local Exchange Carriers, CC Docket No. 01-338 (July 2002) (hereafter "Tardiff").

[42] *UNE Prices and Telecommunications Investment by John Haring, Margaret L. Rettle, Jeffrey H. Rohlfs, and Harry M. Shooshan III, Strategic Policy Research, submitted on behalf of Qwest*, in its reply comments in the Matter of Review of the Section 251 Unbundling Obligations of Incumbent Local Exchange Carriers, CC Docket No. 01-338 (July 2002) (hereafter "Haring, *et al."*).

[43] *Reply Declaration by National Economic Research Associates, Inc. On Behalf of BellSouth Corporation*, In the Matter of Review of the Section 251 Unbundling Obligations of Incumbent Local Exchange Carriers, CC Docket No. 01-338 (July 2002) (hereafter "NERA").

[44] *UNE-P Use and Facilities-Based Competition, in New York and Other States by Howard Ware submitted on behalf of SBC*, Appendix 1 to Reply Affidavit of Alfred E. Kahn and Timothy J. Tardiff, In the Matter of Review of the Section 251 Unbundling Obligations of Incumbent Local Exchange Carriers, CC Docket No. 01-338 (July 2002) (hereafter "Ware").

[45] *UNE-P and Investment*, In the Matter of Review of the Section 251 Unbundling Obligations of Incumbent Local Exchange Carriers, Before the Federal Communications Commission, CC Docket No. 01-338 (July 2002) (hereafter "UNE-P Report").

[46] It is obvious that the ILECs cannot prove their own hypothesis merely by disproving the alternative hypothesis, because there is at least one other hypothesis that must be considered, *i.e*., that unbundling has no significant effect on investment.

2000 or 2001.[47] The superficially plausible argument they offer is that UNE-P rates in 2002 could not have affected behavior in earlier periods. Additionally, they argue that since UNEs only became effectively available after 1999, any ILEC investment that took place before that time ought to be irrelevant to our analysis.[48]

As we described above, we have estimated our regression models using six different sets of UNE price data that were compiled at different times between 1996, when the FCC's First Report and Order was issued, and June 2002. With respect to both the ILEC investment equation and the CLEC activity equation, the strongest results -- refuting the *Investment Deterrence Hypothesis* and confirming the predictions of the *Competitive Stimulus Hypothesis* -- were obtained with the most recent and the earliest sets of data respectively. In the parlance of econometricians, our results are robust to the time period at which the UNE prices were compiled. Thus, as an empirical matter, the critics' objection to our use of UNE-P rates from 2002 is without merit.

Nor, as a theoretical matter are we surprised. The criticism that UNE rates from 2002 are irrelevant to an empirical understanding of investment between 1996 and 2001 neglects the role of expectations in determining investment behavior. Investment is determined by expectations of the future rates that will prevail during the life of the investment. At the time investment decisions are made, information about historical or current rates is combined with other kinds of market intelligence to form expectations of future rates. To the extent that subsequent rates are not determined by unanticipated market developments, those rates provide the analyst, looking back, with an unbiased measurement of the expectations upon which such decisions relied.[49] Thus the effect of the Telecommunications Act of 1996 on ILEC (and CLEC) investment should have begun to have been felt as soon as the Act became law – perhaps even earlier to the

[47] For example, see Haring *et al.*, p. 4, Tardiff p. 2, UNE-P, p. 12 and NERA, p. 60.

[48] See, for example, UNE-P Report, p. 13.

[49] In rational expectations models of economic behavior in markets, decision makers form expectations, conditional on their information, as part of the market equilibrating (*i.e.,* market clearing) process. In a rational expectations equilibrium, the same kind of market forces that match supply and demand operate to eliminate biased expectations. See, for example, Chapter 7 in Chi-fu Huan and Robert Litzenberger, *Foundations of Financial Economics* (North Holland 1988).

extent the Act's requirements were anticipated during negotiations among the principal parties, including the ILECs.

The suggestion that the unavailability of UNEs before 1999 renders the inclusion of ILEC investment before 1999 inappropriate in an empirical analysis of the effect of UNEs also fails to account for the role of expectations. Unless our critics are prepared to argue that between 1996 and 1998 ILECs expected to be able completely to thwart the statutorily mandated UNE process, those firms ought to have expected that eventually they would be compelled to offer access to UNEs at TELRIC-based rates.[50] Thus, it is appropriate to include investment data from these years in our analysis. An additional advantage of doing so is that ILEC accounting data on investment are noisy on a year-to-year basis. Therefore, changes over a longer period of time smooth out random year-to-year fluctuations.

B. Claims Of Omitted Variables And Failure To Control For Certain Effects

Haring, *et al.*, claim that two relevant variables are omitted from the analysis, the number of loops in a state and Gross State Product (GSP), which is a measure of the total amount of economic activity in a state.[51] We consider each of these two alleged omissions in turn.

There is no rationale for adding the number of loops in a state to our specification. The number of loops in a state is one measurement of the size of the telephone network. Because we measure ILEC investment and the ILEC's initial (1996) capital stock in per-capita terms, a variable of this kind is not needed to account for the size of the state. It would, in any event, be a poor measure of state size. If loops in a state were measured in per-capita terms, it would measure the size of the network relative to the size of the population. A state with a high number of loops per capita might be a state in which the relative importance of industries that rely on telecommunications is high. We have

[50] The FCC's TELRIC rules were promulgated in August 1996 in its First Report and Order.

[51] Haring *et al.*, p. 6.

already accounted for that effect by including a variable to measure the share of the labor force employed in such industries. On the other hand, a state with a high ratio of loops per capita might be a high income state in which second residential lines are relatively more common. By including the state unemployment rate in our specification, we have accounted for differences of this kind across states.

Further, we understand that there are substantial problems with the loop data. The FCC does not report for all states when to do so would violate confidentiality of competitively sensitive data (*i.e.*, very few lines) so that reduces the number of states that could be included in the sample. Also, the best source of CLEC line data appears to be the FCC (which aggregates the data that is self-reported by the carriers). Initially, the FCC only reported the number of TSR and UNE loops, and did include estimates of the CLEC lines served using their own capacity. In later periods, the FCC did estimate CLEC lines served using their own facilities, but no longer included estimates of lines via TSR or UNEs in their state-by-state reports. In addition, the FCC data were restated because of substantial over-estimates in earlier reports sometime before June 2001, but the FCC only adjusted the national aggregate estimates so it is impossible to correct for earlier mis-reporting at the state-level.

One way in which the Haring *et al.* criticism that GSP should be part of our specification might be interpreted is a suggestion that the unemployment rate fails to account adequately for differences in the level of economic activity across states. We do not believe that is so, but that is a proposition that can be tested. Therefore, we have gathered data on GSP for each state for the years 1996 through 2000.[52] For each state in our sample, we calculated average GSP over these five years per capita of year 2000 population. We then re-estimated our model using this new variable.

There are two ways in which a new variable like this may be added to the model. On the one hand, because it measures relative economic activity from state to state, it could be seen as a replacement for the average unemployment variable. On the other

[52] http://www.bea.doc.gov/bea/regional/gsp/action.cfm.

hand, one could also specify it as an addition to the average unemployment variable. The attractiveness of doing the latter is that if state-to-state differences in the level of economic activity are too complex to be summarized by one variable, then using both variables will better capture the effect of differences between states. On the other hand, to the extent that both variables measure the same underlying differences, they will be correlated with each other and such co-linearity will produce imprecise estimates.

Therefore, we followed both approaches. In Exhibits 8, 9, and 10 we report the results of re-estimating our model using (i) unemployment alone (as in our original estimates), (ii) GSP per capita alone, and (iii) a combination of unemployment and GSP per capita. Exhibit 8 reports the results of estimating the reduced-form ILEC equation using the AT&T UNE price data. Exhibit 9 reports the results of estimating the ILEC structural equation. Exhibit 10 reports the results of estimating the CLEC structural equation using the AT&T UNE price data.

Exhibits 8, 9, and 10 show that there is no support for the suggestion advanced by Haring, *et al.*, that our findings would be reversed by using data on GSP. The estimates reported in Exhibits 8, 9, and 10 are largely consistent with those in Exhibits 1, 3, and 6. The estimates provide no support for the *Investment Deterrence Hypothesis*, but they do support the *Competitive Stimulus Hypothesis* both in its predictions for the reduced form and in its predictions for the structural forms.

C. Other Claimed Specification Errors

Haring, *et al.* also suggest that our model is improperly specified because the identification of the ILEC structural equation relies on the omission of the UNE prices and TSR discounts from that equation, which they claim should have been included.[53]

[53] Haring, *et al.*, p. 9. A structural equation is said to be "unidentified" or "under identified" in the econometric sense if multiple values of the coefficients being estimated are observationally equivalent to one another. An equation is identified if the assumptions on the system are sufficiently particular. One type of assumption that is commonly considered in evaluating identification is the omission of certain variables from certain equations in a system. Such omissions can enhance the prospect that an equation is identified. For a system to be well specified, such omissions must be well justified on the basis of the underlying economic theory.

Haring and his colleagues recognize that the effect on investment that is transmitted via the level of CLEC activity is accounted for by the presence of the CLEC activity variable.[54] They argue, however, that UNE prices and TSR discounts *directly* affect profit, and so should be included in the investment equation, stating:

> The UNE price and the resale discount both affect ILEC profits directly. The higher the UNE price, the more profit the ILEC makes on sales of UNEs. The lower the resale discount, the more profit the ILEC makes on resold services.[55]

This line of reasoning is faulty, however, because it confuses the effect of UNE prices on *total* profit with the effect of UNE prices on the *marginal revenue product* of capital, which as we explained earlier is what determines the ILEC's incentive to invest. When an ILEC contemplates the addition of an incremental piece of capital equipment to its network in order to increase the quantity or quality of the service it provides to its own customers, the marginal revenue product of that investment is affected by the UNE price, or by the total service discount, through their impacts on the degree of competition facing the ILEC. Hence, these prices do not have an *independent* role in the structural ILEC investment equation, which is identified by means of the variables that are direct measures of CLEC activity.

Haring and his colleagues also suggest that our model is poorly specified because the dummy variables that represent various forms of state regulation should properly be thought of as endogenous.[56] That is, they argue that not only does the form of regulation influence investment, but investment influences the form of regulation. In other words, their view is that investment and regulatory form are simultaneously determined. However, the connections between investment and regulatory form would only constitute a genuinely simultaneous system if *current* investment affected *current* regulatory form and *current* regulatory form affected *current* investment. Even Haring, *et al.* recognize that the influence from investment on regulatory form occurs with a lag. In their

[54] *Ibid.*

[55] *Ibid.*

[56] *Ibid.,* p. 10.

criticism of our model they write, "the state regulator may regulate more stringently or decline to permit price cap regulation based on *past* performance of the ILEC . . . ."[57] An environment in which *past* ILEC behavior influences *current* regulatory form, and *current* regulatory form influences *current* ILEC investment does not create the simultaneity issues for estimation suggested by the critics.

In any event, even if the regulatory form variables were endogenous, it would not make a comparative test of the *Investment Deterrence Hypothesis* and the *Competitive Stimulus Hypothesis* impossible. Although Haring and his colleagues are correct that neither the ILEC reduced-form equation nor the ILEC structural-form equation can be estimated in the forms in which we described them (as explained above), it is possible to estimate modified versions of both equations. In fact, simply dropping the regulatory form variables from the ILEC reduced-form and structural form equations yields equations that can be estimated.[58] The results of carrying out these estimates are shown in Exhibits 11 and 12.

Exhibit 11 shows the results of estimating the modified reduced-form equation using the AT&T UNE price data. Although the fit measured by R^2 is somewhat lower than in our original estimates, the results are otherwise qualitatively similar. The estimated coefficients on the TELRIC and population growth variables are consistent

[57] *Ibid.* (emphasis in original).

[58] If the regulatory form variables are endogenous, and if, as Haring and his colleagues contend, regulatory form is a function of ILEC investment, then the complete system consists of seven equations, *i.e.*, the CLEC and ILEC structural forms and five regulatory regime structural forms, one for each regime. In each of the latter, the regulatory form is a function of demand factors and ILEC investment. In this model, the reduced-form equation for ILEC investment has ILEC investment as a function of the, now smaller, set of exogenous variables from which the regulatory form dummies have been removed. As Haring and his colleagues assert, the ILEC structural-form is not identified. However, an estimable form equation may be obtained by grouping the ILEC structural-form equation with the five regulatory regime equations to make a system of six equations in six variables, *i.e.*, ILEC investment and the five regulatory regime variables. If one were to solve this system for the five regulatory regime variables and substitute the solutions back into the original ILEC structural-form equation, the result would be a modified ILEC structural-form equation that expressed ILEC investment as a function of CLEC activity, demand factors, average revenue and TELRIC prices. Combining this modified ILEC structural-form equation with the CLEC structural-form equation yields a system of two equations in CLEC activity and ILEC investment that is identified and can be estimated. The CLEC structural-form is unchanged from our previous estimates, and the modified ILEC structural-form equation has the same variables as the original ILEC structural-form except that the five regulatory regime variables have been removed.

with expectations, and none of the variables have significant coefficients whose signs are counter to expectations. Because the estimated coefficients on the UNE price are negative and statistically significant, these results refute the *Investment Deterrence Hypothesis* and provide support for the *Competitive Stimulus Hypothesis*.

Exhibit 12 shows the results of estimating the modified structural-form ILEC equation. Again, the fit is more modest than with our original estimates, but the results are otherwise qualitatively similar. The coefficient on population growth is positive (the expected sign) and statistically significant in all four equations. The TELRIC variable is negative and statistically significant in three out of four equations. It is negative without being significant in the fourth.[59] The estimated coefficients on the variables measuring CLEC activity are positive and statistically significant in three out of four sets of estimates.[60] Thus these estimates provide support for the first leg of the *Competitive Stimulus Hypothesis* in that they show a positive relationship between ILEC investment and CLEC activity.

There is no need to produce additional estimates of the CLEC activity equation. It is unchanged in this modified model, so the results from Exhibit 6, which provide support for the second leg of the *Competitive Stimulus Hypothesis*, continue to apply.

D. Claims Of Mis-Measured Variables

Critics of econometric studies often assert that variables are not measured correctly and that such measurement errors cause error in the estimation process. Examples cited by the critics of the current study are: the inclusion of investment necessary to accommodate CLEC entry, the choice of specific metrics for TELRIC, for ILEC investment, and for CLEC activity; and our not limiting our measurement of variables to the RBOC territory in a state. [61]

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[59] It would, however, be significant at the 90% confidence level.

[60] The fourth would also be significant at the 90% confidence level.

[61] Haring, *et al.*, pp. 5, 7, & 8, NERA Report, pp. 57, 59, Tardiff, p. 5.

The model incorporated the best measurements possible for each variable. Each was publicly available and measured in a consistent manner across all states. We rejected measures that we knew were not consistent across states, as with CLEC lines broken down by line types. The CLEC activity measures we chose were those measured by the FCC, and they are the best, most consistent measures available. Likewise, our estimate of TELRIC is taken from the FCC's own cost model and is consistently measured across states.

We also disagree with the suggestion that the measure of ILEC investment ought to exclude investment associated with accommodating CLEC entry. First, whether ILEC investment occurs to serve an active wholesale market or to serve the ILEC's own retail customers is irrelevant. The *Competitive Stimulus Hypothesis* predicts that both sorts of investment will be stimulated, and from a public policy point of view, the distinction is not important. Moreover, measuring ILEC investment on the narrower basis recommended by Haring, *et al.* is, in any event, impossible because the ILECs do not provide the FCC with data that separate CLEC-accommodating investment from general investment.

Finally, although the ILEC investment and UNE-P rate data are restricted to the BOC territories, we did not attempt to restrict our measures of other variables to only those territories because in most cases that would be impossible due to the lack of the requisite data. At worst, the failure to restrict variables to RBOC-only territories would introduce random measurement error that would tend to make it harder to observe significant results. Thus, if we had a reasonable basis for restricting our measures of CLEC activity and other control variables only to the RBOC serving areas, we expect that our results would have been even stronger.

E. Claims Of Incorrect Interpretation

Tardiff articulates two criticisms related to the signs of estimated coefficients in our results. His first objection is with the sign of the estimated coefficient on average

revenue in the CLEC activity equation.[62] He attempts to make much out of the fact that this coefficient is negative, but the negative estimate in that case is not statistically significant.[63] In other words, from a statistical point of view the sign of the estimate is unimportant because the estimate is not statistically distinguishable from zero. Although a positive sign would have been the most plausible, a zero estimate is not unreasonable. The coefficient, after all, measures the effect of *current* average revenue on CLEC activity. To the extent that firms have expectations that the future will be different from the past, the current value of average revenue may not play a large role in their expectations of expected future profits.

Tardiff also complains that there is an "undisclosed assumption" on our part, *i.e.,* that the elasticity of demand for ILEC investment is greater than unity.[64] We have, in fact, built no such assumption into our model or our estimation process. All of our estimates are unrestricted as to their numerical values. Tardiff interprets the results of our estimation as implying that the elasticity is greater than unity. To Tardiff it is unintuitive that demand for investment would be elastic because demand for the underlying telecommunications service is inelastic. Although it might be reasonable to infer that inelastic demand for telephone service would lead to inelastic demand for telecommunications capital *stock*, that does not mean that demand for the *flow* of investment in additional telecommunications capital should necessarily also be inelastic.

V. CRITIQUE OF ALTERNATE ANALYSES OFFERED

A few of the critiques have offered econometric analyses as alternate models of the ILEC investment process. One (authored by Haring, *et al.*) purports to "explain ILEC investment, paying special attention to the effect of the UNE price,"[65] while the other (an unsigned white paper sponsored by a group of RBOCs) purports to show the relationship

[62] Tardiff, p. 4.

[63] See the estimates in the first two regressions reported in Exhibit 6

[64] Tardiff, p. 6.

[65] Haring, *et al.*, p. 11

between UNE-P levels and ILEC investment.[66] Both are flawed and can be given no weight.

Haring, *et al.*, use RBOC net plant, uncorrected by state population or any other measure of the size of a state, as their dependent variable and specify as independent variables (i) the number of RBOC loops, (ii) the number of unemployed persons, (iii) real gross state product and (iv) a variable that is the product of RBOC Loops and UNE Loop prices for Zone 1. Based on this, Haring, *et al.* purport to show a positive relation between net plant and UNE prices.

This regression suffers from a number of serious flaws that stem from the lack of any basis in economic theory for the specification that they employ. First, and most fundamentally, there is an intrinsic element of circularity in the Haring, *et al.* specification. The dependent variable in the regression is RBOC net plant. One of the independent variables included in the regression is the number of RBOC loops. Another is the value of those loops evaluated at UNE prices. However, the RBOC's net plant consists, in part, of those very same loops that are being invoked to explain net plant. Although this specification goes a long way towards guaranteeing that a positive relationship will be found, all it serves to demonstrate is the unremarkable proposition that RBOC net plant increases as loops increase.[67]

Nor is the damage done by this specification limited to the tautological feature of trying to explain a variable by reference to important portions of itself. In order for the estimated coefficients in a regression analysis to be free of bias, the random errors in the determination of the dependent variable must be uncorrelated with the independent variables.[68] The specification employed by Haring, *et al*., where two of the independent variables embody components of the dependent variable, ensures that such correlation is

[66] UNE-P Report, p. 12

[67] Haring, *et al.* claim to use an unspecified "correction for heteroskedasticity." Haring, *et al*., p. 11. A correction for heteroskedasticity cannot, however, make up for the fact that the specification of this model is unfounded in economic theory.

[68] See, for example, Pindyck and Rubinfeld, *supra*, pp. 93 – 97.

present. Thus, even if the Haring, *et al.* estimates could be related to meaningful economic parameters, their estimates would be biased.

Using Haring and his colleagues' data combined with some of our own data, we have re-estimated a corrected version of their regression.[69] The bona-fide relationship that is closest to the specification employed by Haring, *et al.* is the firm's determination of the profit maximizing stock of capital. According to standard economics, this determination would depend on factors influencing demand for telecommunications services, the prices the firm can earn selling those services, and the costs of purchasing those services. Therefore, a theoretically reasonable specification that is as close to the Haring, *et al.* specification as possible would make net total per-capita plant in service a function of gross state product per-capita, population growth rate, the unemployment rate, the share of the labor force in telecommunications intensive industries, average revenue per line, TELRIC cost, and the UNE price.

The results of estimating this model are shown in Exhibit 13. The regression results in Exhibit 13 account for over 78% of the variation in the dependent variable (just under 75% on an adjusted basis), and the statistically significant coefficients, on Gross State Product, population growth rate, and average revenue, all have the theoretically expected signs. The signs on the TELRIC cost and the UNE price variables are not statistically significant. Thus, the Haring, *et al.* assertion that there is a positive relationship between UNE prices and ILEC capital use is refuted.[70]

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[69] The Haring, *et al*. data were obtained from the Strategic Policy Research website at http://www.spri.com/pdf/reports/Qwest/Data.pdf. We supplemented these data with our data for TELRIC prices, share of the workforce in telecommunications intensive intensive industries, population growth, average revenue per line, and the average unemployment rate (as described earlier).

[70] The lack of statistical significance of the estimated coefficient on the UNE price does not provide evidence against the *Competitive Stimulus Hypothesis*. It is a consequence of using the capital stock as the dependent variable rather than *investment*, which is the *change* in the capital stock. It takes time for a firm to make the *investments* necessary to bring its *capital stock* to its optimal level. Because the UNE process is still only a few years old, it is not surprising that the *investment* regressions described in our earlier exhibits show a stronger relationship between investment and UNE prices than does this regression, which may exhibit the relationship only as long term adjustments to the new environment are complete.

Haring, *et al.* attempt to augment their criticism by citing to prior findings in the literature, which they say support their findings and contradict ours. In so doing, however, they overlook both the shortcomings of the prior literature and the support to be found, notwithstanding those shortcomings, for the *Competitive Stimulus Hypothesis* in that literature upon which they rely.

For example, they cite a paper by Eisner and Lehman for an empirical result that "lower UNE prices did not necessarily yield greater CLEC entry."[71] The Eisner-Lehman results are found in an unpublished paper that focuses on entry by CLECs and employs data drawn from mandatory FCC Form 477 filings that are not publicly available.[72] Employing a cross-section sample of 48 states, they estimate models of CLEC entry where the measure of entry is taken to be the number of CLEC lines. They estimate models of facilities-based lines, resale lines, and UNE lines separately as well as estimating a model of all non-facilities based lines (*i.e.,* resale plus UNE-P) and a model of all CLEC lines combined. In each case they report finding that the number of CLEC lines is positively related to UNE prices although their findings are not consistently statistically significant.[73]

Critically, the specification of the estimating equations in Eisner and Lehman's work is *ad-hoc* and unexplained. All they say about their specification is that, "A combination of wholesale prices, retail prices, state demographics, costs, and regulatory variables were used as independent variables."[74] In their estimation of each model the specification is varied, with variables being added to or removed from equations in no apparent pattern and with no explanation by the authors.[75] It is difficult to know why

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[71] Haring, *et al.*, p. 16 (referring to James Eisner and Dale E. Lehman, "Regulatory Behavior and Competitive Entry," 14th Annual Western Conference Center for Research in Regulated Industries, June 28, 2001, www.sbc.com/public_affairs/long_distance_news/california/Lehman_Attach_B.doc) (hereafter "Eisner-Lehman") .

[72] Eisner-Lehman, pp. 5, 6.

[73] Eisner-Lehman, Tables 3 – 6.

[74] Eisner-Lehman, p. 9.

[75] There are 12 variations on the facilities based model, 8 on the resale line model, 8 on the UNE line model, 3 on the non-facilities line model, and 10 on the all lines model. Eisner-Lehman, Tables 3 – 7.

certain variables appear alone or in combination with others and what to expect from their signs. Significantly, however, none of the 41 variations reported include any variables that measure the economic activity that gives rise to the demand for telecommunications service.[76] Omission of a relevant variable, such as the level of economic activity, results in biased regression estimates.

Although Eisner and Lehman had the advantage of access to non-public data from the FCC, those data are now well out of date. Their data on CLEC lines were gathered as of June 30, 2000.[77] Relative to the data we have employed, which reflect CLEC activity a year later (*i.e.*, in June 2001), these data are more heavily influenced by the experience of the relatively early years of implementing the Telecommunications Act of 1996. The ILECs vigorously resisted implementation of the 1996 Act, and it took several years of court and regulatory proceedings to settle even the most basic access obligations.[78] As a result, the UNE prices at those times necessarily served as a poor measure of the CLECs' cost of UNE based entry. This may account for why Eisner and Lehman, themselves, feel that their "UNE models are the least satisfactory, both statistically and intuitively."[79]

In this context, it is particularly striking to note that Eisner and Lehman's findings about the effect of UNE prices on CLEC entry are very different in those states were the RBOC had, at the time of their data, received approval under section 271 of the Act. In those states where the ILEC and the regulators had removed at least some of the non-price barriers to CLEC competition, the relationship they find between UNE prices and CLEC entry was negative, as predicted by theory and confirmed with later data and a better specification by our own results.

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[76] It is true that some variations include a total employment variable, but as both the authors and Haring *et al*. observe (the latter, approvingly), this serves only to correct for the size (called "scale" by Haring *et al*.) of states relative to one another. (If a large state like Ohio is experiencing a recession and a smaller state like South Dakota is not, employment in Ohio will still be larger than employment in South Dakota.) *See* Eisner and Lehman, p. 11; Haring *et al.* p. 16.

[77] Eisner and Lehman, p. 9 and note 9, p. 8.

[78] See, for example, the whole proceeding that eventually led to the Eighth Circuit's decision in *Iowa Utils. Bd. v. FCC,* 120 F.3d 753 (8th Cir. 1997).

[79] Eisner and Lehman, p. 15.

Haring, *et al.*, also cite an article by Ros and McDermott[80] for evidence that "in states where residential and business retail rates were more balanced, there was greater evidence of facilities-based entry by CLECs."[81] But this conclusion is consistent with our results. Further, Haring, *et al.* ignore critical findings reported by Ros and McDermott. In particular, Table 4[82] of their article shows the regression results for three different dependent variable measures of CLEC activity as reported to the FCC as of December 1998. These are: (1) number of CLECs holding numbering codes, (2) percent of ILEC residential lines served by switching centers where new entrants have collocation arrangements, and (3) percent of ILEC other lines served by switching centers where new entrants have collocation arrangements. The variable UNE loop price appears on the right hand side of each equation, has a negative sign, and is significant at the 10% level in the first equation and at the 5% level in other two. This means that the higher the UNE loop rate, the less CLEC activity there is. As imperfect and dated as the data are for this study, that result is certainly consistent with our result and not at all consistent with the assertions of Haring and his colleagues.

Finally, the econometric evidence offered by the UNE-P Report should be rejected out of hand. The UNE-P Report professes to explore the relationship between Total ILEC Investment per line and CLEC UNE-P Lines per 1000 BOC Access Lines. It does so by comparing these variables in a simple regression and concludes that there is no relationship between them, *i.e.,* as more CLEC UNE-P lines appear, there is no more ILEC investment. There are, however, many problems with this analysis. First, it appears from the cursory description provided that in conducting their regression the author(s) of this study confused the level of capital, which is a stock variable, with the amount of investment, which is a flow variable. As discussed, the purpose of the entire analysis is to explain the determinants of investment. To the extent that the UNE-P Report is measuring capital stock, it is simply measuring the wrong variable for its own

[80] Augustin Ros and Karl McDermott, "Are Residential Local Exchange Prices Too Low?," *Expanding Competition in Regulated Industries* Michael Crew, Ed. (Kluwer Academic Publisher: 2000) (hereafter "Ros and McDermott").

[81] Haring, *et al.*, p. 17 (citing Ros and McDermott, p.15-17(sic), which should be p. 167).

[82] Ros and McDermott, p. 163.

purpose. In any event, even if the dependent variable does measure investment, the right-hand side of the equation used in the regression is incomplete. No control is provided for the influence of demand factors, the cost of telecommunications infrastructure, or the effects of regulation. Quite obviously, these variables can have a strong impact on ILEC investment independent of the availability of UNEs. The omission of such highly relevant variables, therefore, means that the estimates obtained are unreliable because they are likely biased. Additionally, we understand that the data relied upon in the UNE-P Report are incomplete and have been "cobbled together" from *ad-hoc* sources when more systematic and complete data are available.[83] We further understand that when these data problems are corrected, the conclusions asserted in the document are no longer supported by the results.

VI. CONCLUSION

The results of our empirical analysis should come as welcome news for regulators and policy-makers, because to the extent that the *Investment Deterrence Hypothesis* finds support, policy makers and regulators would face a trade-off between the current efficiency-enhancing effect of competition and the growth-promoting effect of investment. Fortunately, the empirical evidence we have studied supports the *Competitive Stimulus Hypothesis* and, therefore, no such trade-off is necessary. Regulatory policies that support access to unbundled network elements encourage both competition and investment.

Regulators may take further comfort from the fact that this conclusion is consistent with sound economic theory. As a general matter in economics, competitive markets produce greater output, which leads to greater investment, at lower prices than their monopolistic counterparts. So policy mechanisms like the UNE process, which encourages competition, should also encourage investment. This mechanism forms the basis for recent work by Kotlikoff and Hassett in which they analyze a dynamic and

[83] The underlying data relied upon by in this study is being extensively critiqued in a forthcoming study by AT&T.

strategic model of entry and competition in telecom-related markets.[84] They found, among other things, that telecom competition stimulates telecom investment, a conclusion that is consistent with our finding of empirical support for the *Competitive Stimulus Hypothesis*.[85] The significance they attach to that finding for future economic growth is consistent with our finding that the estimated elasticity of ILEC investment with respect to CLEC prices of between -2.1 and -2.9 means that a 1% reduction in UNE prices may be expected to lead to an increase in ILEC investment of between 2.1 and 2.9%.[86]

[84] Kevin A. Hassett and Laurence J. Kotlikoff; The Economics of Telecom Investment; mimeo, (September 2002).

[85] *Ibid*., p. 4.

[86] *Ibid*., p. 33.